ERS 350 – Freshwater Flows
Spring 2012

Stream-Flow Field Class

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Additional References:

FISRWG. 1998. Stream corridor restoration handbook: principles, processes, and practices. Federal Interagency Stream Restoration Work Group. http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/?ss=16&navtype=BROWSEBYSUBJECT&cid=stelprdb1043244&navid=140100000000000&pnavid=140000000000000&position=Not%20Yet%20Determined.Html&ttype=detailfull&pname=Federal%20Stream%20Corridor%20Restoration%20Han

Gordon, N.D., T.A. McMahon, and B.L. Finlayson. 1992. Stream Hydrology: An Introduction for Ecologists. John Wiley and Sons. New York.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: and illustrated guide to field technique. Forest Service General Technical Report RM-245. U.S. Department of Agriculture. http://www.stream.fs.fed.us/publications/PDFs/RM245E.PDF

<u>Uniform Flow Computations (pg. 620):</u>

Propulsive Force = (W sin θ = γAL sinθ)
Resistive Force = τ P L
Propulsive = Resistive Forces, therefore (γAL sinθ = τ P L)

If S = sinθ (L/L), R = A/P (L) and P = wetted perimeter (L):
γ (A/P) (sinθ) = τ (F/L^2)

(ρ g) R S = τ   (this is the tractive, or shear, force – pg. 631)

If τ = KV^2, then $V(\frac{m}{s}) = \left(\frac{\gamma}{K}\frac{A}{P}S\right)^{\frac{1}{2}}$ or $V = C\sqrt{RS}$
If $C = \frac{R^{1/6}}{n}$, then

Manning Equation (pg. 621):

$V(\frac{ft}{s}) = \frac{1.489}{n}R^{2/3}S^{1/2}$ or $V(\frac{m}{s}) = \frac{1}{n}R^{2/3}S^{1/2}$

Flow State (Turbulence & non-uniform flow):
Reynolds Number (pg. 614)
Re = $\frac{RV}{v}$, where Re = inertia/viscous forces , ν = kinematic viscosity
Laminar – viscous forces dominate (<500)
Turbulent – inertial forces dominate (>2000)

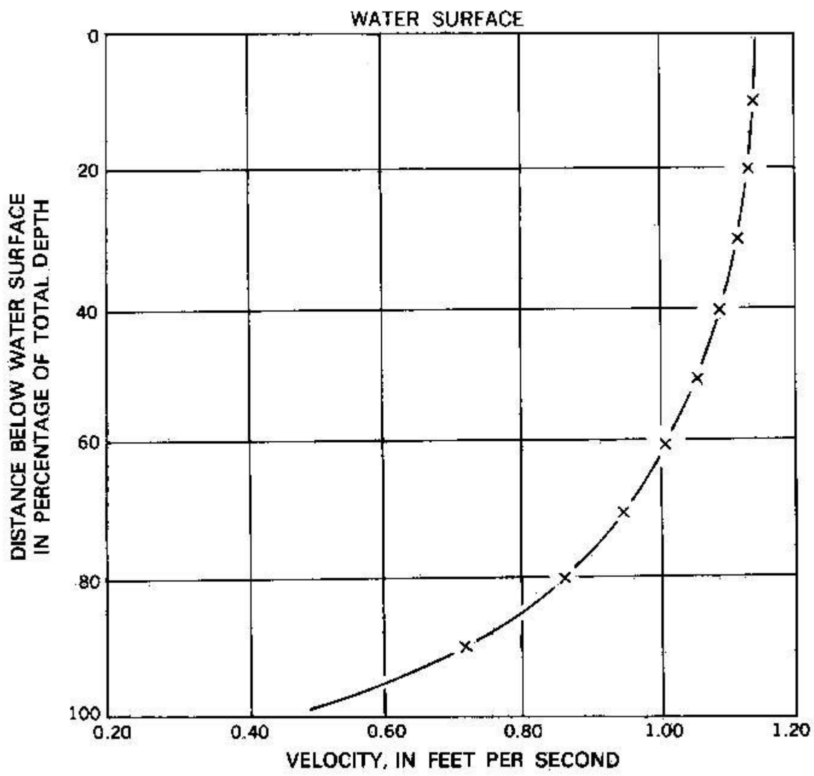
Froude Number (pg. 615):
$Fr = \frac{V}{\sqrt{gD}}$, where D = depth (L)
Subcritical (<1)
Super critical (>1)

Boundary Layer (pg. 292):

$$\frac{v}{\sqrt{\tau/\rho}} = \frac{1}{K} ln\left(\frac{y\sqrt{\tau/\rho}}{v}\right) + C$$

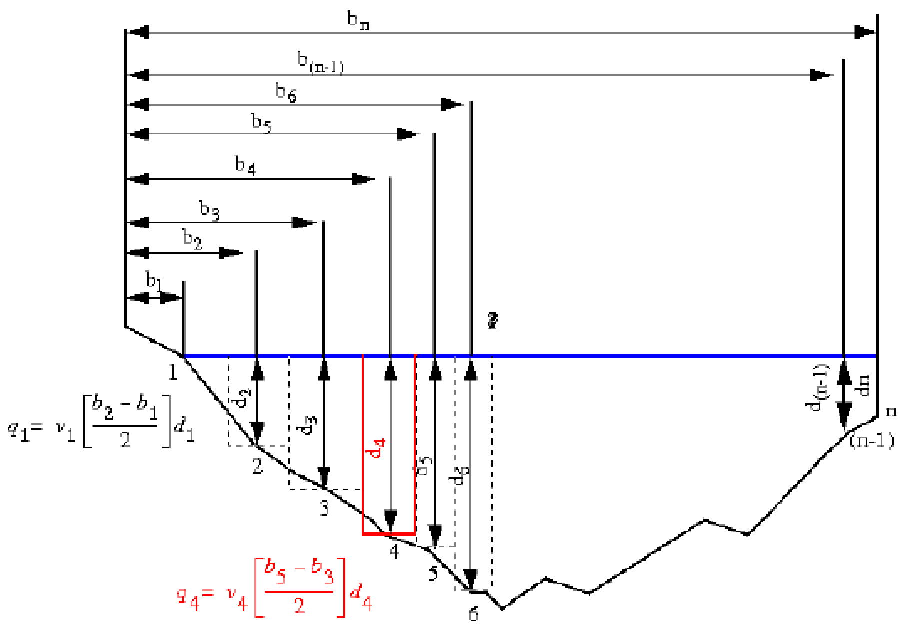
$v = V_0(\frac{y}{a})^{1/m}$, where a = distance above the bed, V_0 =velocity at distance "a" above the bed, m = constant dependent on Reynold's number, y = height above bed.

Velocity Profile: When (depth < ~3ft), then use 0.6*depth down from water surface to bottom



Mid-Section Method (similar to Gupta's version on pg. 305):

Sketch of midsection method for computing discharge



Explanation

1,2,3 ....n --Observation verticals

b_1, b_2, b_3, ...b_n --Distance from initial point to observation vertical

d_1,d_2,d_3,.....d_n --Depth of water at observation vertical

Dashed lines --Boundaries of subsections

$$Q = q_1 + q_2 + \ldots q_n$$

ROUGHNESS (n) CALCULATION (Gupta's version - pg. 623):

Basic n value (n0)	_____
Earth	0.020
Rock	0.025
Fine gravel	0.024
Coarse gravel	0.028
Cobble	0.030-0.050
Boulder	0.040-0.070
Surface irregularity (n1)	_____
Smooth	0.000
Minor (slightly eroded)	0.005
Moderate (moderate slumping)	0.010
Severe (badly slumped, eroded banks, jagged rocks)	0.020
Variation in x-sect. shape causing turbulence (n2)	_____
Changes occur gradually	0.000
Occasional changes from large to small or side to side	0.005
Frequent changes	0.010-0.015
Effects of obstructions (n3)	_____
Negligible (few obstructions)	0.000
Minor (isolated obstructions; less than 15% of area)	0.010-0.015
Appreciable (interaction between obstacles; 15-50% of area)	0.020-0.030
Severe (obstructions cover >50% or cause turbulence over most of the area	0.040-0.060
Vegetation (n4)	_____
None or no effects	0.000
Supple seedlings or dense grass	0.005-0.010
Brushy growths, no growth in streambed	0.010-0.025
Young trees intergrown with weeds; grass twice the depth of flow	0.025-0.050
Brushy growth on banks, dense growth in stream; trees intergrown with weeds; full foliage	0.050-0.10

n_{total} (n_{total} = n0 + n1 + n2 + n3 + n4). _____

Meandering (multiplier) (m5)	_____
Minor (sin: 1.0-1.2)	1.00
Appreciable (sin: 1.2-1.5)	1.15
Severe (sin: >1.5)	1.3

Total product (n = n_{total} * m5) _____

Hydraulic Geometry (pg. 405):

$$w = aQ^b$$

$$d = cQ^f$$

$$v = kQ^m$$

Because width, depth, and velocity are each a function of discharge as described by the formulas above, the three equations can immediately be related to one another through the identity

$$Q = \text{area} \times \text{velocity, or, } Q = wdv$$

substituting from the above

$$Q = aQ^b \times cQ^f \times kQ^m$$

or

$$Q = ackQ^{b+f+m}$$

It follows therefore that

$$b + f + m = 1.0$$

and

$$a \times c \times k = 1.0$$

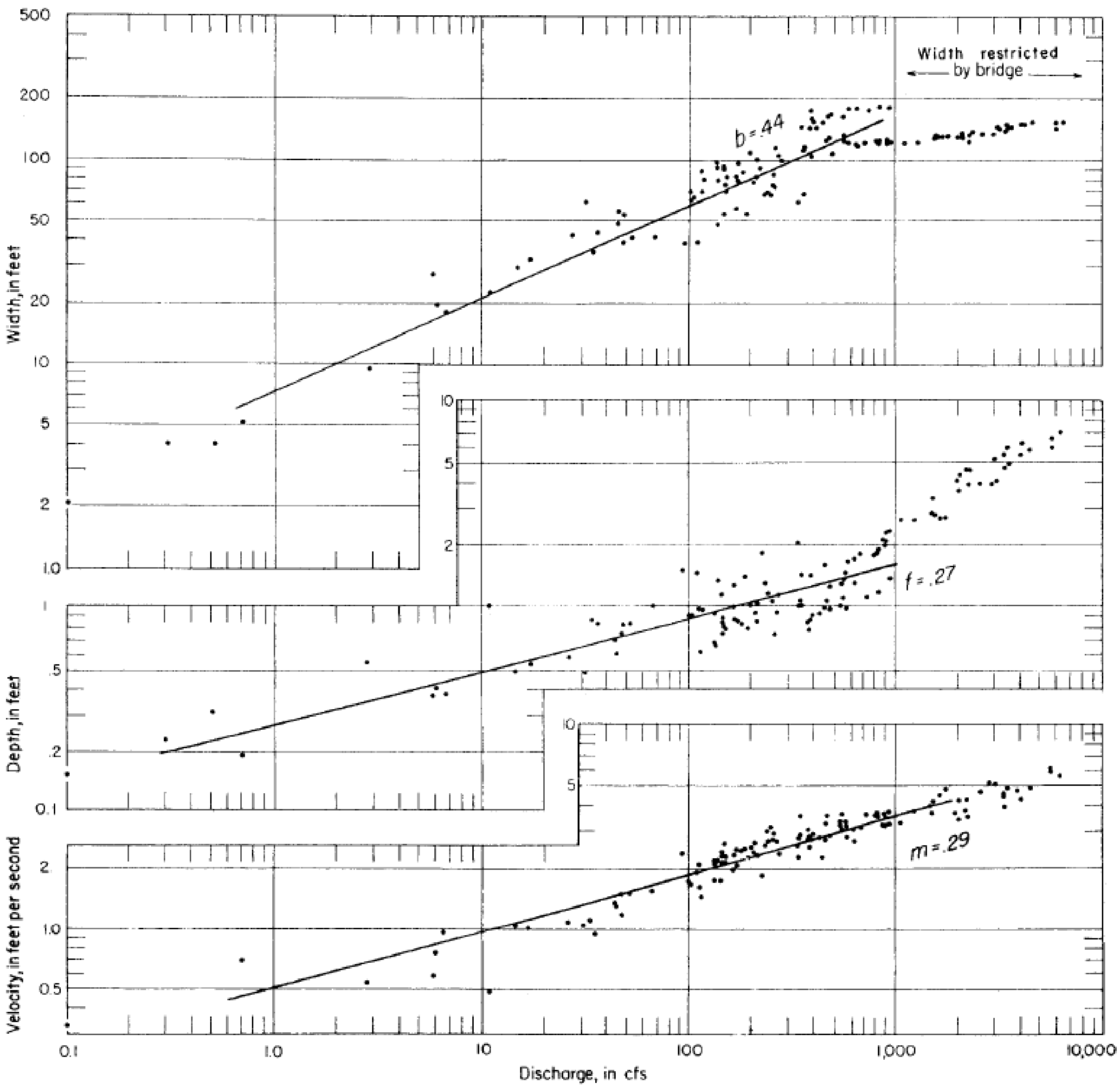


FIGURE 4, *A*.—Relation of width, depth, and velocity to discharge, Powder River at Arvada, Wyo.

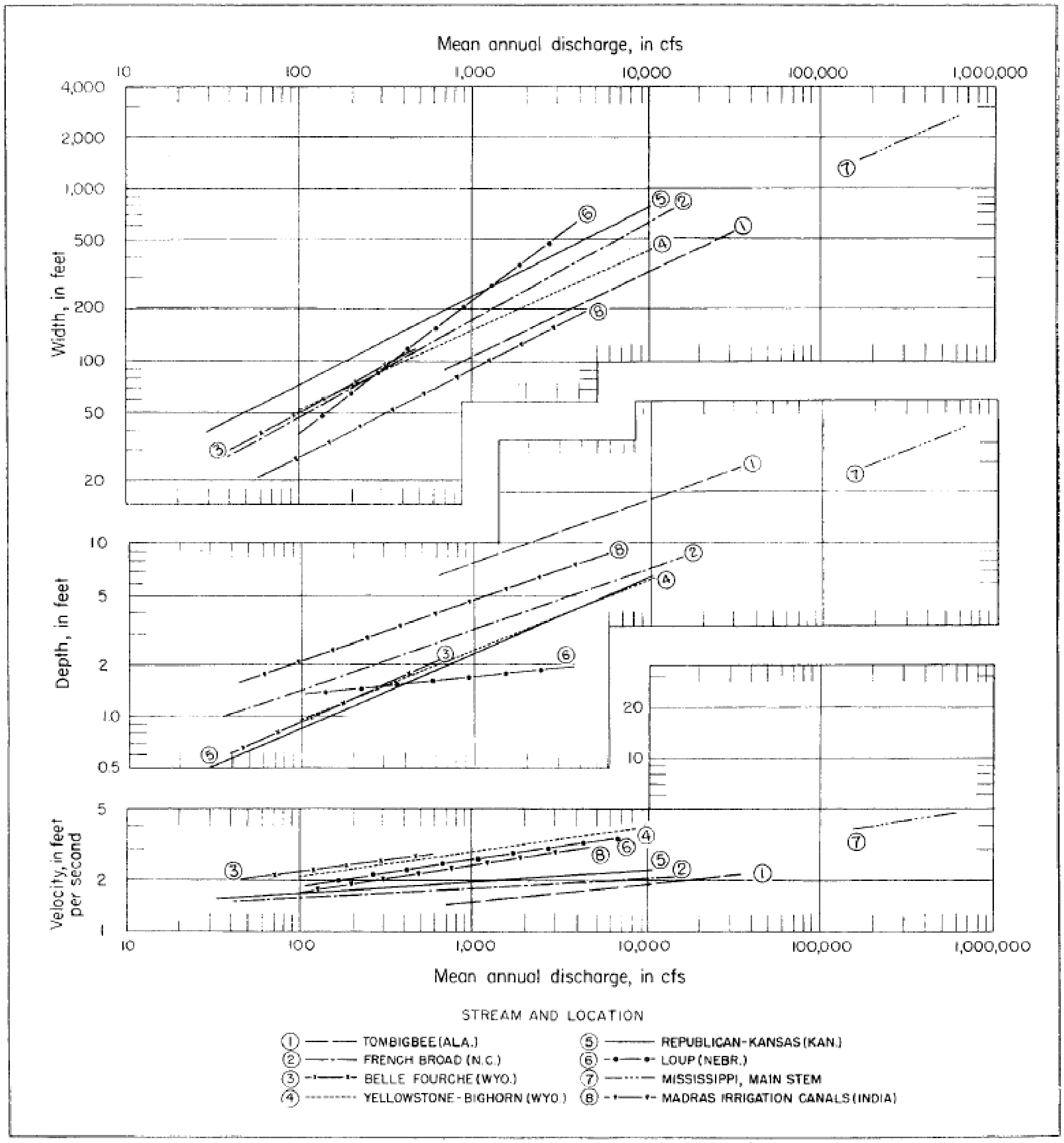


FIGURE 9.—Width, depth, and velocity in relation to mean annual discharge as discharge increases downstream in various river systems.

Discharge Measurement

Date: _________ Stream Reach: ___________________

Station Units: m ft	**Depth** Units: m ft	**Velocity** Units: m/s ft/s	**Notes**

CROSS SECTION SURVEY MEASUREMENTS

Date: ________ Stream Reach: ___________________ Units: _____

STATION Units: m ft	**ROD HEIGHT** (Channel Bottom) Units: m ft	**NOTES**

LONGITUDINAL PROFILE SURVEY MEASUREMENTS

Date:________ Stream Reach:___________________ Units: _____

STATION Units: m ft	**ROD HEIGHT** (Channel Bottom) Units: m ft	**WATER DEPTH** Units: m ft	**NOTES**